<<基本粒子及其相互作用>>

图书基本信息

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作者：（加）金广浩 著

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前言

The last few decades have seen major advances in the physics of elementary particles. New generations of particle accelerators and detectors have come into operation, and have successfully contributed to improving the quantity and quality of data on diverse interaction processes and to the discoveries of whole new families of particles. At the same time, important new ideas have emerged in quantum field theory, culminating in the developments of theories for the weak and strong interactions to complement quantum electrodynam-ics, the theory of the electromagnetic force. The simplest of the new theories that are at the same time mathematically consistent and physically successful constitute what is known as the standard model of the fundamental interac-tions. This book is an attempt to present these remarkable advances at an elementary level, making them accessible to students familiar with quantum mechanics, special relativity, and classical electrodynamics. The main content of the book is roughly divided into two parts; one on theories to lay the foundation and the other on further developments of concepts and descriptions of phenomena to prepare the student for more advanced work. After a brief overview of the subject and a presentation of some basic ideas, two chapters which deal mostly with relativistic one-body wave equations, quantization of fields, and Lorentz invariance follow. In the spirit of the practical approach taken in this book, a heuristic derivation of the Feynman rules is given in the fourth chapter, where the student is shown how to calculate cross-sections and decay rates at the lowest order.The following chapter contains a discussion on discrete symmetries and the concept of symmetry breaking. Isospin is introduced next as the simplest example of internal symmetries in order to ease the reader into the notion of unitary groups in general and of SU(3) in particular, which is discussed next together with the recent discoveries of new particles. The next two chapters present the standard model of the fundamental interactions. We make contact with experiments in subsequent chapters with detailed studies of some fundamental electroweak processes, such as the deep inelastic lepton-nucleon scattering, the CP violation in the neutral K mesons, the neutrino oscillations and the related problem of the solar neutrino deficit, and finally,the r lepton decay, which touch upon many aspects of weak interactions. The very high precision of the data that is now attained in some of these processes requires a careful examination of higher-order effects. This leads to a detailed study of one-loop QCD corrections to weak interactions. The next chapter demonstrates the remarkable property of asymptotic freedom of quantum chromodynamics and introduces the powerful concept of the renormalization group which plays a central role in many phenomena. The heavy flavors of quarks, which pose new questions on several aspects of interactions and could open windows on the 'new' physics, form the subject of a separate chapter.We close with a review of the present status of the standard model and,briefly, of its extensions. Selected solutions to problems are given. Finally,important formulas are collected in an Appendix for convenient reference.

内容概要

The last few decades have seen major advances in the physics of elementary particles. New generations of particle accelerators and detectors have come into operation, and have successfully contributed to improving the quantity and quality of data on diverse interaction processes and to the discoveries of whole new families of particles. At the same time, important new ideas have emerged in quantum field theory, culminating in the developments of theories for the weak and strong interactions to complement quantum electrodynam-ics, the theory of the electromagnetic force. The simplest of the new theories that are at the same time mathematically consistent and physically successful constitute what is known as the standard model of the fundamental interac-tions. This book is an attempt to present these remarkable advances at an elementary level, making them accessible to students familiar with quantum mechanics, special relativity, and classical electrodynamics.

作者简介

作者：（加拿大）金广浩 Quang Ho-Kim Pham Xuan Yem

书籍目录

章节摘录

插图：1.4 SymmetriesThe recent history of physics gives us several examples that illustrate theimportance of the symmetry considerations in explaining empirical observa.tions or in developing new ideas .Thus, the intriguing regularities found in the atomic periodic table can be naturally explained as resulting from the rotational symmetry that characterizes atoms in their ground states；similarly, the relativity theory owes the clarity and the elegance of its fornmlation toits guiding principle, Lorentz in variance .However, more than any other field, particle physics, perhaps because of the very nature of the subject or becauseof the absence of relevant macroscopic analogies or useful classical correspon.dences, has by necessity conferred upon the symmetry concept a key role that has become essential in fornmlating new theories.The existence of the Q-particle and the reality of quarks are two outstanding demonstrations of thepower of this line of reasoning.but no less impressive is the prediction of theexistence of the electronic neutrino by Wolfgang Pauli back in 1 930 solely onthe basis of the conservation of energy, momentum, and angular nlomentum, the validity of which was still in doubt at the time.Pauli took a road less traveled by and opened up a whole new world. The prominent place taken by the symmetry considerations throughout this book only reflects their importance in particle physics.In this section .we will sketch a general picture of the idea. and briefly define various symmetry operations. As we have seen above .every particle js identified by a set of quantumnumbers.These numbers summarize the intrinsic properties of the particleand, for this reason, are called the internal quantum numbers, meaning thatthey have nothing to do with the kinetic state of the particle.which is de.scribed by other conserved quantities that depend on the state the particleis in, such as the energy,momentum, or angular momentum. The existence of a quantum number in a system always arises from theinvariance of the system under a qlobal geometrical transformation.that is。
one that does not depend on the coordinates of the space.time point whereit is applied.A simple example suffices to illustrate the general situation.Consider two particles in a refefence frame iu which their interaction energydepends only on the relative distance of the particles.It follows then, first, that a displacement of the origin of the coordinates by an arbitrary distanceproduces no measurable physical effects on the system, and second, that thetotal momentum of the system remains constant in time because its rate ofchange, given by the total gradient of the interaction energy, is strictly zero.So, generally.if we have a physicaI system in which the absolute positions arenot observable fits energy depending off the relative distance rather than in.dividual particle positionsl and if we apply on it a geometrical transformation（spatial translation）, then we obtain as direct consequences the invariance ofthe systern to the applied transformation（translational invariance）and theexistence of a conservation rule fmomentum conservation）.These are, inshort, the interdepelldent aspects found in every symmetry principle.

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